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TARGETING EMERGING-TECHNOLOGY INDUSTRIES

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PREFACE

Members of the Congress have been concerned that the emerging, technologically advanced industries of the United States are being singled out for government assistance by competitor nations, most notably Japan. At the same time, academic economists have developed a theory to explain how, and under what conditions, similar targeting efforts by the U.S. government can contribute to the overall national welfare. This analysis, undertaken at the request of the Senate Committee on the Budget and the Senate Committee on Governmental Affairs, examines conceptual and practical issues associated with the targeting of emerging-technology industries.

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SUMMARY

Comparative measures of economic performance have caused increasing concern that U.S. industries may not be able to meet the challenges posed by foreign competitors. This concern is particularly acute with regard to emerging industries that are based on advanced technologies and have been targeted by competing nations for government assistance. Over the past decade, the Congress has been asked repeatedly to focus on targeting-related issues, such as funding for research and development, fair trade reciprocity, and the appropriate administration of policies concerning competition. This report examines these issues with regard to industries based on emerging technologies.

TARGETING INDUSTRIES

Targeting is the use of government policies to influence or direct economic resources toward selected industries. Governments practice targeting to achieve a variety of national objectives, among them national security and improved national economic welfare. Strategic trade targeting seeks to increase net national income and employment by creating domestic firms that are competitive in international markets.

Advocates of such targeting believe that maintaining a strong U.S. position in international trade offers a special justification for such government aid. Such aid serves in part as a defensive strategy that would prevent publicly supported foreign firms from extracting economic gains from the United States because, if unchallenged, those foreign firms would gain market dominance and be able to exploit their current technological and marketing leads. The case for targeting emphasizes the presence of market failures--impediments to the efficient allocation of resources in the economy--that should be rectified by government programs. These programs would redirect resources to specific industries that can garner above-average profits and wages, or "economic rents," from international trade. Thus, the benefits from assisting these industries would presumably exceed the costs of the program. Industries based on emerging technologies are viewed as being among the chief candidates for such targeting because they may be expected to develop on the basis of increasing returns to scale and imperfectly competitive markets.

Skeptics about the trade benefits of targeting believe that targeting would be limited to a rare set of circumstances, that governments would have difficulty identifying these circumstances, and that even where the benefits may exceed the direct costs of such a program, the institutional risks--that is, the changes in incentives and behavior--may overwhelm the direct economic calculations. They further argue that most industries proposed as candidates for targeting are no more

characterized by increasing returns to scale and imperfect competition than other U.S. industries. While subsidies would no doubt benefit the industry receiving them, the cost to the taxpayer and consumer would be at least as large as the benefit to the favored industry.

TARGETING IN JAPAN

Advocates point to the success of Japan's economy as proof that targeting works. Skeptics argue just as forcefully that Japan's experience proves the irrelevance of targeting, particularly for the United States. Both sides would agree that government targeting can successfully steer resources to a particular industry. Substantial disagreement exists over whether the net impact of such targeting, taking into account opportunity costs and costs associated with seeking out such assistance, yields net positive benefits to society as a whole. In addition, one could argue that Japan's targeting fails to provide a useful model for the United States, or even Japan, to follow in the future.

The advocates' case is bolstered by the success experienced by Japanese industry under the guidance of a series of government-sponsored plans. Under these plans, the government played an active role in leading the consensus--with industry management and labor--that was one of the key ingredients in making targeting work. This style of targeting required a balanced mixture of cooperation and competition. This balance is viewed by many as just as important to Japan's success as direct government expenditures, which have never been as substantial as is commonly believed.

Critics of targeting emphasize the role of macroeconomic conditions and policy--particularly its strong record of maintaining high rates of saving and investment--in Japan's economic success. Many experts believe that, even without government assistance, the composition of Japan's investment and production, which corresponds with its comparative advantages in abundant skilled labor and capital, would have been substantially the same. Opponents can also list Japan's targeting failures that were costly mistakes and should be factored into the economic accounting of targeting efforts. Finally, opponents argue that even if Japan's targeting was successful in the past, it is not a model for Japan's future, let alone one for the United States, because growth in Japan's technical competence and in its financial markets has overcome the institutional failures to which targeting policies were initially directed.

TARGETING IN THE UNITED STATES

A policy to initiate an explicit targeting program based on calculated gains from international trade would be a new direction for U.S. economic policy. It would justify government support for industry based on trade considerations, although in some ways the only major difference between such a program and current practice

would be in the justifications--trade and commercial competitiveness--and the explicitness of the policy. Most targeted support for industry in the United States now is based on the pursuit of noncommercial objectives such as national security, public health, and space exploration, although some tentative steps have been taken to support technologies on the basis of competitiveness (for example, SEMATECH and the Advanced Technology Program). U.S. policy also tends to be uncoordinated and diffuse.

The Congressional Budget Office examined four emerging industries--optoelectronics, biotechnology, advanced materials, and materials processing in space--to provide a practical basis for understanding the theory of strategic targeting. These industries, which are representative of a larger set, are all targets of foreign government support, are developing constituencies that view them as strategic to the future of the U.S. economy, and now receive some form of support from U.S. government programs. They differ in many ways, including their market size, technological and product maturity, and degree and type of government support. Despite the obvious limits to generalizing from such a small sample, the development of these industries illustrates many of the challenges facing emerging-technology industries, and government policy toward them.

Identifying Strategic Industries

One key difficulty is how to determine whether an industry is strategic and therefore a candidate for targeting. Whether the expansion of an industry produces benefits to society that are not captured by market prices--externalities in production--is an important part of this determination. Industries and firms may generate such benefits for rivals, customers, or suppliers (including labor). For example, when individual firms undertake research and development (R&D), a part of the benefits of their research spills over to competitors. This is one reason why private firms may invest in too little R&D, from society's point of view. The benefits of government support to increase an industry's output will be spread more widely throughout the economy to the extent that the targeted industry has strong and direct linkages with other firms or suppliers. The benefits of a subsidy given directly to one producer may be shifted to another, depending on their relative market power and how the supply and demand for their products responds to price changes. Moreover, subsidies given by one country's government to its domestic firms may eventually flow to firms and consumers in another country if linkages are particularly strong. Thus, the United States benefits when other countries are paying the subsidy, but not when the U.S. government pays it.

"Strategic-ness" may depend more on whether competition is imperfect--that is, whether markets become dominated by one or just a few firms. But the development of markets for emerging-technology industries is very difficult to foresee. The structure of competition depends on a number of factors, including the maturity of the industry, the number of possible substitute products, and the extent of government intervention and support. The theory of strategic trade emphasizes

that markets for technologies characterized by economies of scale will naturally become dominated by a small number of producers. These producers will earn above-average profits and contribute to economic welfare by expanding production to an efficient scale. But industries that exhibit increasing returns to scale are the exception rather than the rule; and it may not be known at an early developmental stage whether scale economies will eventually characterize a given industry.

Uncertainty and Government Activities

Choosing to support an industry or technology because it is thought to be strategic is a risky decision, filled with uncertainty. Part of this uncertainty is technological (Can experimental products be made practical and reliable?), and part is economic (Will the market accept the product, and at what price?). Financing the development of an emerging-technology product provides an opportunity to reap the benefits of success and at the same time entails bearing the risk of failure if those uncertainties cannot be overcome. Who should bear those risks and benefits is a fundamental question in the evaluation of government activities that support emerging-technology industries.

All governments of the industrialized nations provide some support to a nearly identical list of high-technology industries. In most cases, the amount of direct financial support is not large enough to guarantee winning a strategic monopoly (or oligopoly) in the international marketplace. But the range of activities supported is quite broad: support for R&D is the most typical and most direct policy; other policies include procurement and standard setting. The largest costs of government support usually are borne by consumers and nonsupported industries.

Current U.S. policy is best described as generally relying on favorable macroeconomic conditions and competitive markets to ensure that decisions concerning resources and technologies are made in accordance with principles that maximize economic welfare. This policy does not exclude, however, nontargeted government support for general activities such as R&D or targeted support for specific technologies and products needed by government agencies in pursuit of their primary missions. Aside from some recent efforts, it excludes the strategic trade argument as a special justification for such support.

Neither the targeting debate nor economic theory provides a conclusive basis for deciding whether emerging-technology industries need special assistance to create economic advantages based on trade. Theory holds that targeting to achieve gains from trade can increase national income, but only under very special conditions that may be difficult to foresee or to produce.

Policymakers must decide whether to continue to support emerging high-technology industries within the current policy and institutional framework, or to modify that framework to favor an explicit trade-oriented strategy based on the principles of targeting such industries. One option that has received Congressional

attention is to support emerging industries on a "target of opportunity" basis. In this approach, targeting theory helps inform judgments made by government, but only in the sense of providing a trade rationale for a more general program of government support--one that would aid applied research that improved the ability of U.S. firms to compete in international markets. Such assistance would not be made to "pick winners," but rather to support a diversified portfolio of projects. Some projects in the portfolio may "win," but even the "losers" could be expected to create the same public benefits that are generally associated with other science and technology activities. A government agency based on a combination of characteristics derived from the National Science Foundation (NSF) and the Defense Advanced Research Projects Agency (DARPA) has been proposed to operate and fund this policy.

CHAPTER I
TARGETED INDUSTRIES

Many measures of economic performance and welfare show that Japan, Germany and other European nations, and even several developing nations such as Korea are closing what were once very large gaps with the United States. Of particular concern has been the decline in the trade performance of a number of U.S. manufacturing industries. Initially this decline was evidenced in older "smoke stack" industries, such as steel. But during the 1980s, the U.S. position deteriorated in newer, high-technology industries, that, despite acknowledged U.S. leadership in basic science and technology, could not yield commercial successes. Concern is now being focused on the next generation of high-technology products, whose markets are not yet fully developed. Many observers fear that the United States will lose these markets, even as they begin to emerge.

Partially in response to these concerns, the Congress has approved new federal programs that attempt to enhance the competitiveness of specific high-technology industries. In 1987 the Congress authorized funding for Sematech, a Department of Defense (DoD) program to support the development of semiconductor production technology for the commercial market.[1] Proposals have also been made to extend this approach to other industries and technologies such as high-definition television and high-temperature, superconducting integrated circuits. Supporters of these initiatives argue they are necessary to overcome failures in the private marketplace and, even without such failures, to enable U.S. firms to compete on a level playing field with foreign businesses, in particular Japanese businesses, that receive government benefits and protection. Opponents of such support for emerging industries and technologies contend that the government's role should be more restricted, and that past efforts in the United States and abroad have been largely unsuccessful--if not for the favored industries, then for the larger economy. Moreover, opponents fear that extensive use of government support worldwide could undermine the institutional foundations of international commerce that have contributed to the post-World War II growth of the U.S. economy.

TARGETING

Industrial targeting is commonly defined as the use of government policies to influence or direct economic resources toward selected industries to help them become more competitive in international markets.[2] Targeting strategies for high-

1. Congressional Budget Office, *The Benefits and Risks of Federal Funding for Sematech* (1987), Chapter I.

2. U.S. International Trade Commission, *Foreign Industrial Targeting and Its Effects on U.S. Industries, Phase I: Japan*, USITC Publication No. 1437 (October 1983), p. 19.

technology industries seek to increase net national income and employment by creating domestic firms that are internationally competitive in terms of product prices, quality, and innovative performance. Governments practice targeting to achieve such national objectives as national security, national prestige, and increased national economic welfare. U.S. government support of some high-technology industries aims to achieve a variety of targeting objectives. The Sematech program, for example, is justified by its enhancing of the defense industrial base, its contribution to trade goods, and its support for scientific research and understanding.

Targeting can be achieved through a variety of policy tools (described briefly in Box 1). Governments have applied these policies explicitly in coordinated strategies, and haphazardly in uncoordinated preferential programs. Industrial targeting strategies pursued by some governments focus the policy tools on particular firms and reward these firms for behavior that conforms to the government's expectations. Industry participation in the formulation and execution of industrial strategies is seen by advocates of targeting as important to its success.

The objective of industrial policy may be expansion, contraction, or even abandonment of a national industry. For high-technology industries, expansion is the usual objective. Strategies directed toward these industries have emphasized promotion of research and development, thus smoothing the process of technological discovery from basic scientific research to commercial adaptation and, ultimately, to the production of new products that can compete in international markets.

The role of government targeting in creating emerging industries has been the subject of considerable debate. Economic and political theory encourages a skepticism about the ability of government to make specific industry-level investment decisions that leave the entire national economy better off, both in total economic benefits and in the distribution of those benefits, than if private investors were making such decisions. Yet, it has been accepted national policy to encourage certain types of activity common to all industries, for example, investment in research and development. Moreover, national security concerns have led to direct investment in, and encouragement of, specific industries or technologies deemed necessary for the nation's defense--nuclear energy and computers, for example. And government support and regulation are critical to many other industries, particularly service industries such as aviation and financial services.

The current debate moves these targeting issues to the arena of international trade, essentially asking whether trade offers a special justification to government intervention. Advocates of targeting contend that identifiable technologies and markets can be exploited to the benefit of the nation as a whole, if government directs resources to these industries.[3] Moreover, advocates hold that if the United

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3. Paul R. Krugman, "Introduction: New Thinking about Trade Policy," in Paul R. Krugman, *Strategic Trade Policy and the New International Economics* (Cambridge, Mass.: MIT Press, 1986), pp. 1-22.

BOX 1
Tools of Targeting

Home Market Protection

Restraint on foreign investment gives domestic firms a market advantage in the domestic market and permits greater national control of a targeted firm or industry.

Tariffs are a tax on imported goods to increase the cost of these goods relative to that of domestic goods by increasing the relative price of imports.

Quotas restrict the quantity of imported goods, permitting domestic producers a larger market and higher prices for their goods.

Discriminatory government procurement provides a market for domestic firms that is free from foreign competition.

Tax Policies

Special depreciation rules increase the after-tax profits of targeted firms by allowing differential and rapid expensing of capital expenditures.

Exemptions or deferrals for export earnings are an incentive to domestic firms to export that increases the after-tax profit associated with exports relative to other activities and grants the recipient a potential cost advantage relative to international competitors.

Tax credits may be granted for specific activities such as research and development that lower the cost of these activities and encourage larger commitments.

Antitrust Exemptions

Permitting or encouraging mergers that create domestic firms capable of achieving a scale sufficient to be internationally competitive.

Permitting or encouraging cartels, agreements among firms to establish industrywide prices and to divide markets, capacity, and profits.

Permitting or encouraging joint or industrywide research and development consortia by allowing firms to pool resources, in some cases with public resources, to attack technical issues generic to the industry.

Science and Technology Assistance

Direct grants to firms or industry groups to conduct research and development activities.

Subsidized or cost-free access to public research facilities and personnel, effectively lowering the cost of research and development.

Government research financed by and undertaken by government with the explicit purpose of creating national economic advantage.

Support in acquiring foreign technology by imposing technology transfer requirements on foreign firms wishing to invest in the domestic economy.

Restricting the participation of foreign firms in national science and technology programs, thus permitting domestic firms differential access to the results of national science efforts with commercial potential.

Financial Assistance

Direct grants for start-up or support of the general activities of a targeted firm.

Loans at subsidized rates providing below-market financing to targeted firms or their customers.

Loan guarantees that, by placing the full faith and credit of a national government behind a targeted firm (or its customer), allow it access to credit it otherwise would not have.

Giving preferential access to credit to national firms at or below market rates unavailable to other potential borrowers.

SOURCE: U.S. International Trade Commission, *Foreign Industrial Targeting and Its Effects on U.S. Industries, Phase 1: Japan*, USITC Publication No. 1437 (October 1983), p. 20.

States fails to establish itself in certain key technologies, its losses to foreign producers will transcend the current generation of goods and services, because advantages in research and development may be cumulative--that is, once producers fall behind in the technological race, they can never catch up. Opponents argue that even in theory targeting is appropriate in only a very few cases, and that in practice a variety of risks related to actual relationships could lead to costly failures if the United States were to undertake a broad program of targeting.[4] In response to concerns that foreign targeting creates losses for U.S. producers, opponents point to offsetting gains for U.S. consumers.

Successful targeting would have to create benefits in excess of its cost, not only for the targeted industry but for the whole economy. This calculation involves many subtleties. Government can certainly direct resources to specific industries and, in doing so, enhance their sales, employment, profits, and innovative record. The key question is under what circumstances the benefits to the favored industries and firms will exceed their cost to the larger economy. A second question is how the gains and losses from targeting are distributed throughout the economy.

The net benefits of targeting should be measurable as the differences in an industry's sales, employment, and profits with and without government support. The costs of targeting are best thought of as the lost alternative contribution of the resources steered by government to the targeted industry, that is, the gains that would have occurred if these resources had been used elsewhere in the economy. If a strategy of targeting protects the domestic market and results in price increases for consumers, these price increases appear both as widely dispersed losses to consumers and as concentrated gains to producers. The net cost, or benefit, is calculated as the difference between these gains and losses. In addition, resources devoted to gaining government support, such as lobbying, must be added to the costs.

From the government's perspective, costs and benefits must be aggregated and evaluated across all of the targeted industries, and over time, as the effects of targeting may take years to occur. In addition, because targeting would change established institutional relationships and incentives--for example, in domestic financial markets and in international trade agreements--the indirect effects of embracing a national strategy of targeting high-technology industries on these institutions need to be included in the calculation of costs and benefits.

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4. Gene M. Grossman, "Strategic Export Promotion: A Critique," in Krugman, *Strategic Trade Policy*, pp. 47-68.

TARGETED INDUSTRIES, THE TRADE DEFICIT, AND U.S. COMPETITIVENESS

Whatever the potential of targeting emerging industries and technologies may be for the long-run competitiveness of the U.S. economy, it will not play a role in reversing the U.S. trade deficit in the short run. The U.S. net exports of goods and services stood at negative $37.5 billion (in 1982 dollars) in 1990.[5] In 1980 the same account registered a surplus of $57 billion (in 1982 dollars). There is no evidence to indicate that a sudden change in the efficiency, productivity, or innovativeness of domestic industry played a significant role in this deterioration, or that foreign government targeting rapidly increased during this period. Rather, the differing macroeconomic policies of the United States and its trading partners explain most of the gap between exports and imports. The large U.S. federal deficit and relatively high U.S. interest rates led to an appreciation of the dollar that caused the domestic price of U.S. imports to fall and the foreign price of U.S. exports to rise.[6] As the U.S. economy expanded during the 1980s, the demand for imports grew faster than the demand for exports, thus creating the trade deficit.

The fall in the dollar's value since 1985 has begun to reverse this process. But the U.S. economy cannot be described as competitive if the trade account is balanced by sacrificing the standard of living.[7] Further declines in the value of the dollar could accelerate the process of trade adjustment, but ultimately at the expense of U.S. living standards if net exports increase because the real wages of U.S. workers fall and U.S. incomes stagnate. While many factors affect the standard of living, the productivity of domestic resources is one of the more important ones. It is through a linkage with productivity that emerging industries and targeted federal support for these industries becomes an issue in competitiveness policy.

The application of technical innovations to existing industries and the fast growth of new industries sometimes created by technical change are among the most significant contributors to productivity increases in technologically advanced nations.[8] Increases in productivity permit existing resources to produce more output for domestic consumption and allow domestic producers to offer lower prices, making them more competitive with foreign firms in both domestic and international markets.

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5. *The Economic Report of the President 1991*, Table B-2, on a national income and product account basis, preliminary figure.

6. Congressional Budget Office, *Using Federal R&D to Promote Commercial Innovation* (April 1988), Chapter 1.

7. George N. Hatsopoulos, Paul R. Krugman, and Lawrence H. Summers, "U.S. Competitiveness: Beyond the Trade Deficit," *Science* (July 15, 1988), p. 299.

8. Angus Maddison, "Growth and Slowdown in Advanced Capitalist Economies," *Journal of Economic Literature* (June 1987), pp. 649-696.

A CONCEPTUAL BASIS FOR TARGETING

The current discussion of targeting draws together two long-standing concerns of economic policy and theory: the role of government in ensuring that the economy reaches its full potential in the presence of imperfect markets, and the role of international trade in national economic growth.[9] Advocates of targeting argue that conditions in international markets and the characteristics of emerging technologies require government intervention, and that only if such intervention occurs can international trade make its maximum contribution to U.S. income and employment.

The case for targeting emphasizes the presence of market failures that prevent economic resources from being most productively employed. Under the umbrella concept of market failures are factors that impede the efficient allocation of resources in an economy. These factors include the absence of markets, unequal distribution of information among producers and consumers, the characteristics of technology, the existence of social or public goods, and the ability of large firms and unions to influence wages and prices. In market economies, the justification for government intervention in private markets is usually the presence of a market failure. By intervening to correct the failure, the government seeks to enable the economy to reach a higher level of income and employment than would have been possible had the market been left to proceed on its own course. The conceptual argument for targeting holds that in selective cases, governments can redirect resources to specific industries to produce net benefits for the national economy.

The rationale for targeting selected emerging industries is that they are "strategic industries" that can be identified and effectively promoted by government, so that the resulting outcome meets the conceptual criteria for successful targeting --that is, total benefits exceed total costs. Strategic industries, though not precisely defined, characteristically are:[10]

- Technologically dynamic, placing above-average emphasis on research and development and competing primarily in the innovation of products and processes;

- More likely than the average industry to experience economies of scale in their own production or to generate benefits that spill over to other industries; and,

- Capable of generating above-average profits or "rents" that can be captured by, and for some significant time confined to, the domestic economy.

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9. Robert Baldwin, eds., *Trade Policy Issues and Empirical Analysis* (Chicago: University of Chicago Press, 1988), p. 1.

10. Congressional Budget Office, *Federal Financial Support for High-Technology Industries* (June 1985), pp. 13-17.

For the advocates of targeting, each of the last two points suggests a role for government policy. By encouraging investment in industries with the potential for spillovers or externalities, the economy can reach higher levels of income and employment. Similarly, national income can be increased if domestic producers can earn above-average profits in international trade.[11]

Externalities

Private markets are most effective when prices fully represent the social value of the output produced and the resources necessary to produce them. When one producer's activities contribute to another producer's output, but the contributing producer is not compensated in the market, prices no longer reflect social values. This situation, referred to by economists as a technological externality, is often cited as a reason for government to subsidize research and development. A private firm will invest in research and development (R&D) only to the extent that it expects gains to be reflected in its balance sheet. This calculus fails to account for the positive effect that the investing firm's research will have on the output of firms benefiting from the externality. Major research breakthroughs--for example, the microprocessor--have had this type of effect. Regardless of patent protection, the original investing firm cannot appropriate the full benefit of the innovation. The general knowledge created increases the value of the output of upstream and downstream producers without compensating the original firm. Government subsidy can compensate for the market's failure to value the externality by encouraging the original firm to increase its R&D spending.

Beyond direct investment in R&D activities, targeting advocates point to other technological externalities that are thought to be associated with emerging high-technology firms, primarily the availability of specially skilled labor and the accessibility to information outside of market transactions. The diffusion of information (including that embodied in skilled labor) by emerging-technology industries tends to occur initially within a localized setting and tends not to be fully captured by market prices. Thus, initial technological advantages in one product or firm are transmitted through informal information networks, initial supplier and distributer relationships, and labor markets to create unpriced advantages to other firms producing similar products or using the same resources.

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11. See Barbara J. Spencer, and James A. Brander, "International R&D Rivalry and Industrial Strategy," *Review of Economic Studies*, vol. 50 (1983), pp. 707-722; Elhanan Helpman and Paul R. Krugman, *Market Structure and Foreign Trade: Increasing Returns, Imperfect Competition, and the International Economy* (Cambridge, Mass.: MIT Press, 1985). See also Rachel McCulloch, "The Challenge to U.S. Leadership in High-Technology Industries (Can the United States Maintain Its Lead? Should It Try?)," National Bureau of Economic Research, Working Paper No. 2513 (February 28, 1988); and Kyle Bagwell and Robert W. Staiger, "The Sensitivity of Strategic and Corrective R&D Policy in Oligopolistic Industries," National Bureau of Economic Research, Working Paper No. 3236 (January 1990).

The linkages among firms and workers revealed by current market transactions provide a road map indicating how external effects from a targeted industry might spread through these markets. Some linkages are strong and direct--for example, those between suppliers of raw materials and their users. Others are less so--for example, the contribution of a more computer-literate work force to all industries. The case for targeting a specific industry is improved to the extent that externalities in production are anticipated and these effects spill over to a wide array of industries.

Economic Rents

A related justification for government support of a strategic industry is the prospect of capturing economic rents in the international market.[12] Economic rents, which are generally associated with above-average profits, include higher-than-normal payments for any or all resources used in production--land, labor, and capital--in the form of additional rental payments, wages, and profits (or interest). Above-average wages and profits gained by the targeted industry in international trade allow the advocates of targeting two claims: first, that the net national income is increased because rents are extracted from foreign rather than domestic consumers, mitigating the concern that a successful targeted industry will merely redistribute domestic income; second, that alternative uses of the resources in other industries will likely yield lower returns, and that not only the targeted industry but the national economy as a whole will receive net benefits from the government's action. Opponents of targeting are quick to point out, however, that above-average returns in successful industries need to be balanced against losses in unsuccessful ones.

One way to earn an economic rent is to be the first producer capable of bringing a product to the market (or, in the case of process innovation, the only producer capable of making a product in a certain way). These so-called "first movers" have an advantage that they can sustain so long as other producers cannot imitate their new products or processes. Patent laws are one way that governments help protect innovators. This protection can be eroded if the technology spreads to competitors, or sustained if the initial advantage is followed by economies in production. Some recent economic literature points out, however, that even when unprotected by patents, technology may be difficult to imitate. The knowledge necessary to imitate is as much embodied in specific people and the organization as it is in readily transferable technical data or engineering specifications.[13]

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12. Richard Baldwin and Paul Krugman, "Industrial Policy and International Competition in Wide-Bodied Jet Aircraft," in Robert Baldwin, *Trade Policy Issues and Empirical Analysis* (Chicago: University of Chicago Press, 1988), pp. 45-78.

13. Giovanni Dosi, "Sources, Procedures, and Microeconomic Effects of Innovation," *Journal of Economic Literature*, vol. 26 (September 1988), pp. 1130-1131.

Having production costs that are significantly lower than those that actual or potential competitors can attain is a second source of rent that may be captured by a targeted emerging industry, and one that is related to the generation of externalities in production. A significant cost advantage enjoyed by a firm or a national industry can deter the entry of new competitors and offer not only short-term rents but also the prospect of sustaining them over time.[14] Learning economies (that is, the process of lowering costs through experience) and increasing returns to scale (that is, lowering costs as production volume increases) are two sources of such cost advantages.

Engineering studies of some manufacturing processes have found that unit costs fall as cumulative production volume increases. These studies attribute this cost decrease to "learning by doing," that is, the improvement in workers' skills, or the management of a production process, that comes from experience. Common industry examples of the effect of such learning include the production of aircraft and integrated circuits. If lower costs can be secured by increased production volume, then a single producer (or a small group) might be able to price its output below that of potential competitors and, at the same time, earn above-average profits. In the extreme case, the cost advantage of the learning leader, once gained, deters actual or potential competitors and is limited only by the growth of the market.[15] In this case, a credible targeting strategy can confer an advantage by enabling the aided industry to gain the initial lead and hold it.

Increasing returns to scale in production can create above-average returns in a way similar to learning by doing. In this case, the technology of production, rather than cumulative production experience, gives the large-scale producer a per unit cost advantage sufficient to price below competitors but above economic costs and to claim a large share of the total market. Increasing returns to scale can be viewed as a special case of technological externality in which the benefits are captured by the producer that generates the external benefit. Competitors are deterred from entering the market by the sheer size of the commitment necessary to do so and to produce a competitively priced product, and by the likelihood of being defeated in a price war against the market incumbent.

One of the key issues analysts and policymakers confront is whether initial technology advantages or market leads generating above-average profits are sustainable. The advantages granted through being first to market, through learning, or through increasing returns to scale may be limited to a particular product and its

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14. Frederick M. Scherer, *Industrial Market Structure and Economic Performance* (Boston: Houghton Mifflin Company, 1980), Chapter 8.

15. A. Michael Spence, "The Learning Curve and Competition," *Bell Journal of Economics*, vol. 12 (Spring 1981), p. 62, concludes that learning can be a substantial barrier to entry, particularly when learning occurs at a moderate rather than a very quick or very slow pace. A simulation provided by Spence also suggests, however, that even a limited number of producers will reduce the level of economic profits in some types of markets in which learning is a major competitive factor.

production. Substitutes for the product and improvements by competitors may diminish the firm's ability to sustain an above-average profit. The historical landscape is filled with the wreckage of firms that were unable to sustain their advantage in the market, as competitors found a way to catch up, go around, or leapfrog the front-runner's advantages.

Many advocates of targeting argue, however, that in high-technology industries increasing returns to scale are evident in the process of innovation itself. That is, as firms in an industry progress through generations of product and process innovations, they learn how to produce the next innovation more quickly and cheaply.[16] Within an individual firm, the innovative process may benefit from indivisible assets (large facilities or teams of research scientists) and from the regularity of the search process for additional innovations. This point is most graphically illustrated in industries like electronics and advanced materials, whose patterns of innovation are well established and whose products appear to go through rapid generational change. For example, the dominant pattern of innovation in the electronics industry has been efforts to increase the number of circuits on an area of semiconductor material and then to manufacture the new product with as low a defect rate as possible.

FOCUS OF THE ANALYSIS

This report analyzes the economic benefits claimed for targeting. The policy debate on targeting is increasingly focused on economic objectives, which are more controversial than the accepted objectives of national security and prestige that motivate most current government actions affecting high-technology industries. Economic targeting is different from many current national security efforts that, in pursuing their primary objective of advancing technology for defense systems, also increase the competitiveness of U.S. firms. Specifically, targeting for advantages in international trade has as its primary objective improving economic welfare--for society as a whole--and should be judged according to that standard.

16. Dosi, "Sources, Procedures, and Microeconomic Effects of Innovation," pp. 1127-1128.

CHAPTER II
HAS TARGETING WORKED IN JAPAN?

Substantial disagreement exists over whether the historical record actually provides evidence of successful targeting. The discussion of targeting in Japan from the mid-1960s to the present is the most prominent case in point.[1] The success of Japan's economy over the last 30 years is held by advocates of targeting to be the paramount proof that targeting can work. Opponents of industrial targeting argue just as strongly that Japan's success illustrates the irrelevance of targeting, claiming that success was achieved in spite of the government's attempt to steer the market. Within this range of opinions is a view that portrays major parts of Japan's experiences with industrial targeting as responses to limited market failures and technological backwardness. According to this view, once these market failures were overcome in subsequent economic development, they no longer required the attention of government. This view, and that of observers disinclined to believe targeting was ever a major factor, question whether Japan's past targeting practices are a model for the United States to emulate, or even for Japan itself to continue in the future.

MACROECONOMIC GROWTH AND INDUSTRIAL SUCCESS IN JAPAN

The dimensions of Japan's economic success can be measured in both macroeconomic terms and at the industry level. During the 1970s, Japan's growth in gross national product (GNP) and productivity exceeded that of the United States, the Federal Republic of Germany, France, and Great Britain. The rapid growth of the Japanese economy began in the 1950s, with per capita gross domestic product (GDP) doubling between the mid-1950s and 1963. By 1987 the purchasing-power-adjusted per capita GDP for Japan was 80 percent of that for the United States and almost 95 percent of the West German level.[2] During the 1970s these successes were achieved despite an adverse change in the terms of trade--the price of the oil Japan imported increased more rapidly than the price of the manufactured goods

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1. Jagdish Bhagwati, *Protectionism* (Cambridge, Mass.: MIT Press, 1985), p. 98, notes the persistent and widely different interpretations among economists of Japan's economic success in formulating the following economic law: "Economic miracles are a public good; each economist sees them as vindication of his pet theory."

2. Purchasing power parity is based on an estimate of the dollar/yen exchange rate that would allow a consumer to buy the same basket of goods in each country. Bela Balassa and Marcus Noland, *Japan in the World Economy* (Washington, D.C.: Institute for International Economics, 1988), p. 4, provides these data for 1975 purchasing power at year-end exchange rates for 1987. Subsequent appreciation of the yen has further narrowed the gap between U.S. and Japanese purchasing-power-adjusted GDP.

Japan exported--and slow growth in the export markets critical to Japan's overall economic growth.

Exports and investment stand out as leading sectors of Japan's economic growth. Exports grew from 11 percent of GDP in 1973 to over 16 percent in 1985. Japan's near-balanced trade account in 1973 registered a surplus of $90 billion by 1986, $55 billion of which was with the United States. Japan's rates of investment and saving exceeded those of its industrial competitors during the period, and as a consequence the Japanese capital stock grew at a rate twice that of any other developed economy between 1973 and 1985.[3]

The export performance of particular industries is also striking. From 1960 to 1980, Japan increased its share of world steel production from 6.5 percent to 15.5 percent, of auto production from 5 percent to 30 percent, and of color televisions from zero to 50 percent.[4] Japan also registered impressive gains in the production of integrated circuits, the building blocks of virtually all modern electronic products, increasing its share in the world market from about 10 percent in 1974 to about 40 percent in 1986.[5] Japan's share of world technology-intensive exports increased from 7.3 percent in 1965 to over 20 percent by 1984.[6]

The sequence in which Japan's industries have made gains illustrates Japan's evolving comparative advantage. Early gains were made in lower-skill, labor-intensive industries. Later, skilled-labor-intensive industries such as automobile manufacturing rose to prominence. Finally, during the 1980s, gains were made in research-intensive industries. As Japan moves into these frontier industries, it confronts new territory in which technical leadership, rather than product modification and process innovation, will be the primary elements of success.

JAPAN AND THE CASE FOR TARGETING

As evidence that targeting can work, advocates of targeting point to Japan's success in high-growth industries and the sequence of industrial successes following the strategies established in various national planning documents. Moreover, Japan's experience is held to be a superior demonstration of the effective use of various

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3. Balassa and Noland, *Japan in the World Economy*, Chapter 1.

4. Daniel I. Okimoto, "The Japanese Challenge in High Technology," in Ralph Landau and Nathan Rosenberg, eds. *The Positive Sum Strategy* (Washington, D.C.: National Academy Press, 1986), p. 542.

5. Congressional Budget Office, *The Benefits and Risks of Federal Funding for Sematech* (September 1987), p. 15.

6. National Science Foundation, *International Science and Technology Data Update 1986* (Washington, D.C.: National Science Foundation, 1986), p. 58.

policy tools to achieve specific objectives of targeting, without extraordinary public expenditures or undue intervention in the domestic and international markets. Thus, advocates find within Japan's experience a model both for an active government role in steering industrial investment and for the economic and political agreement among government, industry, labor, and universities necessary to make targeting a success.

Meeting Planned Targets

Beginning in the 1950s, a series of planning documents announced the intention of the Japanese government to encourage the growth of specific industries. Many of these targeted industries actually grew, and these successes are the focus of the advocates' case. The Five-Year Plan for Economic Self-Reliance and the New Long-Term Economic Plan of the 1950s emphasized the key role of steel and presented a strategy for growth. Japan became an internationally competitive steel producer during the 1960s. A similar plan emphasizing the automobile industry, the National Income Doubling Plan of the 1960s, preceded the take-off of this sector. The Basic Direction of Trade and Industry Plan in the 1970s emphasized Japan's need to become competitive in knowledge-intensive industries and preceded success in the electronics industry. In 1981, the Next-Generation Industries Basic Technologies Project reenforced the themes of the 1970s and emphasized the need for Japan to continue investing in knowledge-intensive industries, including computers, aerospace, and biotechnology.[7]

The claim that targeting has succeeded in Japan can be examined in light of the discussion in Chapter I of the conceptual basis for targeting--resting on economic rents and externalities. One study summarizes a number of different views by noting that although neither of the target industries of steel and integrated circuits was characterized immediately by above-average profits, the industries for which they provide key inputs--automobiles and computers--were provided low-cost materials and, in some periods, experienced above-average profitability. In the case of semiconductors, earlier losses may yet be offset by future gains, as Japanese firms are now increasing their world market share and the potential to hold market price above a competitive (normal) level.[8] Strong linkages and above-average profitability do not constitute a definitive case, however. The study does not consider either the cost of targeting failures or the counterfactual claim that the industrial growth achieved in targeted industries would have occurred in any case.

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7. Balassa and Noland, *Japan in the World Economy*, p. 38.

8. Balassa and Noland, *Japan in the World Economy*, p. 41.

Targeting Practices

The specific policy tools used to promote targeted industries have varied across industries and over time as Japan's role in the world economy has expanded. A brief history of Japan's targeting of the computer industry is presented in Box 2 and illustrates the evolution of tools and institutions used to promote that particular industry. Several generalities about the practices and tools of targeting employed by Japan are worth noting because they are important in considering the case for targeting.

Japan's style of targeting requires a mixture of cooperation and competition.[9] Even before an industrial policy is formally defined, extensive informal negotiations take place among the various parts of the government, the financial sector, public enterprises, and industrial companies to develop a consensus as to the ends and means of policy.[10] Cooperation among firms and between the government and industry was necessary in steering the internal research efforts of individual firms to avoid duplication (for example, the division of responsibility between computers and peripherals created in various phases of the national effort to target the computer industry). Competition among Japanese firms was promoted in the domestic market through competitive procurement by the government and public enterprises, and by keeping open the possibility of introducing foreign competition into protected markets. This balance between competition and cooperation is viewed by observers as just as important an ingredient of Japan's success with targeting as direct expenditures.

The level of the government's direct financial support of industry has not been as substantial as some observers of Japan have suggested.[11] The Japanese government provides less direct research and development support than the United States, when measured as a share of GNP.[12] Japan's contribution is greater, however, if U.S. government support for national security is excluded. Experts do not agree about the levels of support offered to particular industries at particular times in Japan, but the consensus is that when all direct and indirect mechanisms are taken into account, Japan's support for its targeted high-technology industries currently is comparable with that provided by other advanced nations.[13] Direct

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9. U.S. International Trade Commission, *Foreign Industrial Targeting and Its Effect on U.S. Industries Phase I: Japan*, USITC Publication No. 1437 (October 1983), p. 10.

10. Daniel Okimoto, "Regime Characteristics of Japanese Industrial Policy," in Hugh Patrick, ed., *Japan's High Technology Industries: Lessons and Limitations of Industrial Policy* (Seattle: University of Washington Press, 1986), pp. 42-43.

11. Congressional Budget Office, *The GATT Negotiations and U.S. Trade Policy* (June 1987), p. 54.

12. U.S. International Trade Commission, *Foreign Industrial Targeting*, p. 9.

13. Patrick, *Japan's High Technology Industries*, p. xii.

BOX 2
Japan's Targeting of the Computer Industry

The details of Japan's program in electronics have been presented in a number of sources, and the rise of Japan's firms in the world electronics market is well documented.[1] The experience illustrates the array of tools that a government can use to support an industry, the way the mix of these tools can be changed as circumstances change, and the difficulty of separating the effects of targeting from other economic events and policies.

Japan's Electronics Industry Development Provisional Act of 1957, which created an institutional framework for supporting the electronics industry, authorized various forms of financial assistance and granted selective relief from antimonopoly laws.[2] Along with management of technology imports during the 1960s and 1970s, protection of the domestic market, and government-supported procurement, the measures specified in the act were the major tools of targeting used by Japan to boost its electronics industry from its modest position in the early 1960s to its current status of principal rival with the United States for world leadership.

The Japanese government's targeting of electronics was initially focused on the computer industry. Success in computers required progress in integrated circuits, an early target of government-subsidized research. During the 1960s, the Ministry of International Trade and Industry (MITI) coordinated the protection of the domestic industry and at the same time leveraged foreign firms' access to the Japanese market against partnership with Japanese firms and the transfer of technology from U.S. firms to their Japanese partners. This technique was again employed in the 1970s in producing integrated circuits. Financial assistance was also offered in the form of support for cooperative research involving the private Japanese firms, the government (MITI's labs), and the national telephone company, Nippon Telephone and Telegraph (NTT).

(Box continued)

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1. See, for example, Kenneth Flamm, *Creating the Computer: Government, Industry, and High Technology* (Washington, D.C.: Brookings Institution, 1988), Chapter 6; Kenneth Flamm, *Targeting the Computer: Government Support and International Competition* (Washington, D.C.: Brookings Institution, 1987), Chapter 5; U.S. International Trade Commission, *Foreign Industrial Targeting and Its Effects on U.S. Industries, Phase I: Japan*, USITC Publication No. 1437 (October 1983), pp. 131-138; Marie Anchordoguy, "Mastering the Market: Japanese Government Targeting of the Computer Industry," *International Organization*, vol. 42, no. 3 (Summer 1988), pp. 509-543; Michael Borrus, Laura D'Andrea Tyson, and John Zysman, "Creating Advantage: How Government Policies Shape International Trade in the Semiconductor Industry," in Paul R. Krugman, ed., *Strategic Trade Policy and the New International Economics* (Cambridge, Mass.: MIT Press, 1986); and Kozo Yamamura, "Caveat Emptor: The Industrial Policy of Japan," in Krugman, ed., *Strategic Trade Policy*.

Demand for Japanese products was maintained by a combination of protectionism, direct government procurement, and indirect support for private purchasers of Japanese equipment through the Japan Electronic Computer Corporation (JECC), an intermediary capitalized at favorable interest rates by the Japan Development Bank. JECC purchased computers from the manufacturers and subsequently leased them to users. Private Japanese consumers benefited by obtaining favorable lease rates and did not have to bear the risk of technical obsolescence in an industry characterized by rapid technical change. Manufacturers were relieved of the burden of carrying inventories and in effect were given an interest-free loan because JECC paid up front rather than over the three or more years typical of computer leases at that time.[3] Although procurement policy protected Japanese firms from technically superior foreign competition, it was deliberately implemented to force competition among the small group of Japanese firms targeted by the government.

Despite these efforts in the 1960s, Japan's computer industry probably would not have been able to face the challenges of the 1970s--the IBM 370 Series and the end of direct protection of the domestic market--without continuing government assistance. Most observers emphasize the government's role during this period in consolidating the Japanese industry by reducing the number of computer manufacturers to three, each teamed with peripheral and component manufacturers, and by subsidizing both collaborative and individual-firm research and development.[4]

As government subsidies of research and development increased during the early 1970s, procurement and protection tools seemed to decline in importance. In 1976 the Very-Large-Scale Integrated Circuit (VLSI) program was initiated to improve Japan's integrated circuits and manufacturing technology. During the 1980s, cooperative efforts continued, most notably the Fifth Generation computer and the artificial intelligence project. In general, these targeting activities were less intrusive than earlier efforts.

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3. Anchordoguy, "Mastering the Market," p. 521.

4. Flamm, *Targeting the Computer*, pp. 132-133.

financial support has been strategically used, primarily to support generic research and technology programs. Less direct forms of financial aid have been employed in the form of low-cost (concessionary) loans. Both types of financial aid have been used strategically at critical times in the development of the targeted domestic industries. As Japan has progressed economically, the role of direct subsidies to targeted industries has diminished, but spending on public-sector technology activities such as space and university research is on the increase.[14]

In a similar vein, Japan's current level of protection of its domestic market, as measured by tariffs, is no greater than that of its industrial competitors, including the United States. Even nontariff barriers, though considered to be high relative to those in the United States, have not been growing. But as in the case of direct financial support, protection of domestic markets has also been applied strategically, usually in the early period of a targeted industry's development (see, for example, the role of protection in the computer industry, Box 2). Although such protection reduces competition, the threat of permitting foreign firms to enter the domestic market can be used to encourage competitive behavior among Japan's producers.

JAPAN AND THE CASE AGAINST TARGETING

Opponents of targeting interpret Japan's overall and industry-level successes differently than do the advocates of targeting. Opponents emphasize the role of macroeconomic conditions and policy, primarily in the areas of saving and investment, in Japan's success. Rather than beginning with government policy and planning, those who view targeting as less important in Japan's growth emphasize the dynamism of the private sector and its willingness to take risks and at times oppose the wishes of government planners. Finally, opponents of targeting raise several issues concerning the historical record of "successful" targeting in Japan.

The strong saving and investment performance of the Japanese economy overall is acknowledged by both opponents and advocates of targeting to be a key factor in Japan's success. Opponents of targeting argue that the composition of investment and its performance in the market would have been substantially the same with or without targeting. This view attributes Japan's success more to its essential comparative economic advantages, which include products dependent on skilled labor and abundant capital, than to the ability of planners to foresee market developments. Of course, this argument can never be proved.

Just as the advocates of targeting point to the historical record of successes in targeted industries, the opponents of targeting list Japan's failures in aluminum,

14. Budget of Japan's National Air and Space Development Agency, various years.

computer software, energy technology, and pharmaceuticals.[15] In these instances, the cost to the public of targeted support has not been offset by industry-level and economywide benefits. Moreover, Japanese firms have enjoyed considerable success in industries such as consumer electronics that were not explicitly targeted by planners.[16] Skeptics of targeting also note that the most substantial industrial gains attributed to targeting occurred in the 1960s and early 1970s, when Japan was in a catch-up phase in most technologies and more able to use the aggressive subsidy policies and trade protection that would probably not be acceptable in the current international economic environment. Moreover, in the context of Japan's relative economic position at that time, these policies appear to be nothing more than the time-honored practice of protecting an infant industry.

The view that Japan's targeting was successful in the past, particularly in the 1960s and 1970s, but is not a model for the future for Japan--let alone the United States--emphasizes the unique circumstances under which Japan enjoyed success in targeting. Unlike those who observe no benefits from targeting, proponents of this view accept the advocates' claim that targeting was successful in its day and was an effective means of overcoming specific institutional failures in Japan's economy and in its technological backwardness. Political cohesion is seen as a key element of success, because the uninterrupted dominance of the Liberal Democratic Party allowed a disciplined and consistent application of industry support.[17]

Growth in Japan's technical competence and the development of its equity and financial markets have largely overcome the institutional failures against which Japan's targeting policies of the 1960s and 1970s were directed. As Japan looks beyond imitation and application of existing basic science and technology, the market failures it confronts have changed and so it has changed its policies accordingly.[18] Specifically, public investment in large-scale science and technology is increasing, as are broad-based industry consortia involved not in the adaptation of technology already shown to have commercial benefit, but in the exploration of basic science and technology with an uncertain potential for commercial success.

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15. Gary R. Saxonhouse, "Industrial Policy and Factor Markets: Biotechnology in Japan and the United States," in Patrick, *Japan's High Technology Industries*, pp. 97-135.

16. Okimoto, "The Japanese Challenge in High Technology," p. 548.

17. Okimoto, "Regime Characteristics of Japanese Industrial Policy," p. 42.

18. Patrick, *Japan's High Technology Industries*, p. xviii.

CHAPTER III
TARGETING IN THE UNITED STATES

The ongoing discussion of targeting in the United States is motivated largely by the fear that targeting of emerging-technology industries by Japan and other competitors will put U.S. businesses in those industries at a disadvantage and thereby affect future national well-being. Currently, most government support for U.S. businesses is offered under rationales that are not related to trade. Initiating targeting programs specifically to improve international trade would represent a new policy direction in the United States. Several new U.S. efforts represent very tentative movements in this direction. Among these efforts are SEMATECH (a research consortium of U.S. semiconductor producers and suppliers of semiconductor manufacturing equipment), several related consortia proposals, and other new programs within the Department of Defense, the Department of Commerce, and the National Science Foundation.

The targeting debate has not produced a sound economic rationale for such a shift in policy direction. In theory, targeting to achieve gains from trade can increase national income, but only under very restrictive conditions that may be difficult to achieve outside of textbooks. When those conditions are not met, targeting is likely to reduce overall economic welfare by redirecting resources that could be used more productively elsewhere in the economy. Practical arguments based on Japan's experience provide some support for targeting, but the Japanese model of targeting, cast even in its most favorable light, is probably secondary to macroeconomic policies in explaining past successes, and may not, even in the view of many generally supportive observers of Japan's industrial policy, represent a blueprint for Japan's future.

EXPERIENCES OF EMERGING INDUSTRIES

To provide a practical basis for understanding the theory of strategic targeting developed in Chapter I, CBO examined four industries that are based on emerging technologies. In this section, these four industries--optoelectronics, biotechnology, advanced materials, and materials processing in space--and the federal programs that support their development, are used to illuminate some of the key economic and policy questions posed by strategic targeting proposals.

These industries were chosen as an illustrative rather than a comprehensive or exhaustive set of emerging high-technology industries. They share some characteristics: they are all targets of foreign government support, each has developed a constituency that views it as a strategic industry for the future of the U.S. economy, and each now receives some form of support from U.S. government programs. But there are also important differences among these industries, including their market size, technological and product maturity, and degree and type

of government support they receive. Thus, there are obvious limitations to the generalizations that one might draw from studies of their experiences. Nevertheless, these four industries, described briefly below, illustrate many of the challenges facing emerging high-technology industries and those who evaluate them.

- **Optoelectronics** use photons (light) as a vehicle for carrying information. The use of photons would supplant the use of technology based on electrons, which some experts argue is approaching the limits of its utility.[19] Optoelectronics are generally used as components of larger systems such as computers. Key uses for these technologies include gathering, manipulating, storing, and transmitting information.

- **Biotechnology** uses living systems to develop commercial products and processes. Broadly defined, biotechnology includes both old processes (such as the use of yeast in fermentation) and new technologies that rely on duplication of the genetic code in various organisms. Biotechnologies have been used most extensively in the medical and pharmaceutical industries, including the production of hormones, vaccines, and blood-testing diagnostics. The use of biotechnology in other sectors has not progressed as quickly, particularly in agriculture. Although many biotechnologies, especially genetic engineering procedures, are the direct outgrowth of federally funded biomedical research, an extensive private research, production, and marketing sector has developed over the last 10 years.

- **Advanced structural materials** include a variety of nonmetallic substances that are already replacing metals in a number of applications.[20] Thus far, these materials--primarily ceramics, polymers, and composites--have been used as a substitute for traditional materials because they are lighter, stronger, or more durable. Over time, engineers and designers will probably develop new uses and applications that go beyond simple substitution.

- **Materials processing in space** takes advantage of the low gravity (microgravity) or perfect vacuum condition found in Earth's orbit to develop and, in the future, to manufacture superior or new materials

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19. Because pure light technologies have not yet been devised, most systems that now use light are really hybrids, using both electrons and photons. Systems that use photons to control electrons, or electrons to control photons are called optoelectronics. Other terms in common use are photonics and electro-optics.

20. These materials, sometimes called "new materials" or "advanced engineering materials," can also be used in nonstructural applications. For a good introduction and analysis of these materials, see Office of Technology Assessment, *Advanced Materials by Design* (June 1988).

for use in such industries as pharmaceuticals, electronics, metals, and plastics. Virtually all such research is subsidized by governments. Private industry has not yet been convinced of the value of microgravity processing. Predictions of multibillion-dollar markets made in the early 1980s have yet to be realized.[21]

Are These Industries Strategic?

A strategic industry must be technologically dynamic, have the potential to generate positive externalities, and capture and hold within the domestic economy the economic rents earned in international trade. To determine whether the four industries discussed here have these characteristics, one must answer three questions:

- Do these industries have the potential to generate positive technological externalities?
- Are there rents to be earned in the international market, and can they be sustained?
- Does government targeting have a role if the potential for sustainable rents exists?

Technological Externalities

Each of the four emerging industries could produce and enjoy technological externalities as it expands. Each is a science-based industry in which major technological breakthroughs are aggressively pursued. Nevertheless, from society's point of view, private firms in each industry arguably underinvest in research because they cannot capture all of the benefits of a successful innovation. These externalities could occur in both product and labor markets.

A breakthrough product in advanced materials created by one firm can lower the cost of innovation to a competitor simply by demonstrating feasibility. In the most immature of the four emerging industries studied--the processing of materials in space--this effect could prove quite powerful. Moreover, in prominent areas of research to develop advanced materials--for example, structural ceramics--innovations are fairly easy to copy by making small, but legally significant, changes in chemical formulas or production processes. While imitators of new materials receive the benefits of innovations, they do not pay the original innovating investors for these benefits.

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21. Congressional Budget Office, *Encouraging Private Investment in Space Activities* (February 1991), Chapter IV.

The positive external effects of progress in the four emerging industries are also likely to include the benefits to society of expanding the supply of specialized workers--scientists, engineers, and research technicians--that occur when a firm invests in research or training. These effects on the labor market include both the increased productivity available to all employers when the work force improves and the lower cost of gaining new knowledge when workers move from business to business. In both biotechnology and electronics (the larger sector of which optoelectronics is a part), specialized workers move from firm to firm and, in some cases, even establish new businesses. Linkages through the pool of specialized labor extend to suppliers and users as well.

The finding that the social value of increased investment in the four emerging industries is likely to exceed its private value is a necessary but not sufficient argument for targeting. Policies that support research and development (R&D) in general encourage additional investment that allows society to take advantage of these externalities. In the case of biotechnology, in particular, current and planned efforts through the National Institutes of Health may be sufficient to close any deficiencies in society's total investment in this area, without targeting those investments on specific technologies.

Rents

The question of whether there are rents to be earned and how they can be captured is complicated by a number of factors. It is difficult to predict whether or not new products and processes will become technically and economically feasible. Moreover, once initial obstacles have been overcome, the character of the market in which an innovation must compete changes. In workably competitive markets, economic rents will not be sustainable. In less competitive markets, however, imperfections persist and rents may be sustained. But the mere existence of such markets does not by itself prove the case for targeting strategic industries, because the role of government in creating such markets is far from clear.

Uncertainty. There is no guarantee that an emerging industry or technology will be successful, but some are more likely to succeed than others. Biotechnology, for example, is now fairly well established; microgravity processing, however, may never prove economically viable. To succeed, these industries and technologies must pass at least two major hurdles: one is technological, the other is economic. Technological success is necessary for a product to garner economic rents, but it is not sufficient. The product must also become economically successful, with the benefits accruing domestically.

In emerging industries, new technologies and new products hold great promise for future economic gains. If successfully developed, they would supplant similar current products and technologies. Thus, the path to economic gain in these industries typically lies with the resolution of one or more technological problems.

If researchers fail to solve them, the industry cannot develop. In advanced ceramics, for example, researchers must learn how to prevent common stresses and cracks from causing catastrophic failure; in optoelectronics, researchers must solve such fundamental problems as how to place numerous optical components on integrated circuits.

Technological uncertainty is one of the key stumbling blocks to market development. Buyers generally want products that are reliable, not experimental. Many technologies may appear to be promising if only some particular problem could be solved. There are no guarantees, however, that problems can be solved or, that once solved, an additional problem will not be created. Because of the uncertainty of technological research, economists argue that R&D investments should be spread among the widest possible portfolio of projects. Expanding the research portfolio increases the chances that some supported projects will succeed and decreases the risk of total failure. A more concentrated research portfolio, such as that suggested by targeting, could produce a large payoff, but carries with it a higher risk of a large loss.

Even after the successful resolution of technological problems, emerging industries face significant economic hurdles. New products must be priced low enough to compete with the traditional products they seek to supplant, but high enough to recoup investment and reward risk takers. One of the first pharmaceutical products relying on biotechnology--a drug to treat heart attack victims--has proved clinically effective, but is far more expensive to produce than the equally effective rival drug it seeks to displace. Unless governments are willing to subsidize production indefinitely, there must come a point at which a targeted industry can economically produce on its own--indeed, this is the premise of targeting. To do so, firms must not only advance the development of their own product, but be able to fend off the traditional competitor they seek to displace and the potential new competitors who may try to leapfrog their product with one even newer and more technologically advanced.

Capturing and Sustaining Rents. High risks and high returns to innovation are the rule in biotechnology, optoelectronics, and advanced materials. These above-average profits, however, are extracted from both domestic and international markets. In some cases, they tend to rise and fall as a new product moves from infancy to maturity. In biotechnology, patent protection affords a degree of relief from competitive pressures, helping new products command high returns. Yet, even drugs or new materials protected from direct imitation are not immune to competition from new products. Examples of both very short-lived and persistent high returns can be found in the electronics industry. New generations of semiconductors, for example, have commanded high returns for only short periods as competitors have proved able to innovate and overcome both the original innovators' advantage of being first to market and the associated head start in achieving scale and learning economies. By contrast, IBM's line of mainframe computers has commanded high returns for decades, despite many foreign efforts to target the market.

Strategic trade theory emphasizes the role of scale and learning economies in creating rents and allowing them to be sustained. Such cost advantages in production allow a small number of producers to dominate a market. They also discourage new competitors from entering. But for most emerging industries (such as those examined in this study), scale economies in production are not a factor in their initial development--or it cannot be known at so early a stage whether they will become a factor. Indeed, historically, few technologies have exhibited the necessary "increasing returns to scale."

A factor weighing against above-average returns in all four emerging technologies is the presence of similar products and processes. Each of the emerging industries seeks to replace existing products and technologies: space processing competes with Earth-based products; biotechnology, while producing some unique products, has standard technology substitutes; the new materials seek to replace the older ones; and optoelectronics seeks to substitute in many applications that now use solid-state electronics. As these industries develop and reach new levels of performance or create new products, the older products may be less able to compete with them. Their competitiveness will depend, of course, on the product's price, which is a critical factor in the competition between the newer and older products. It will also depend on the response of producers of the older products, who can be expected to resist encroachment in their markets. Steel producers, for example, are doing whatever they can to hold onto their customer base, particularly in automobiles, by developing new products and technologies of their own.

If a more aggressive targeting policy were implemented, controlling the leakage of R&D to foreign competitors could be difficult. This difficulty is compounded by the problem of determining whether a firm is domestic or foreign, or ensuring that a supported domestic firm is not purchased by a foreign one. The global interconnections among the firms engaged in these emerging technologies--through mergers, joint ventures, licensing agreements, subsidiaries, and simple buyer/seller transactions--blur the distinction between foreign and domestic producers. The firms that produce new materials, for example, tend to be large multinationals like Dupont, 3M, and Union Carbide. Some of the products are developed in the United States by foreign-owned firms like BASF, Hoechst, and Philips. And many of these producers have joint-venture or technology-licensing agreements with foreign partners. R&D supported in one country may easily become embodied in production from another: the benefits flow both ways. Many U.S. products, including laser printers and computers, use as inputs products that were subsidized and developed by foreign firms.

Finally, the extent to which gains (rents) are shared with the rest of the economy through industrial linkages may not be easily determined. Gains earned by one firm may ultimately be shared with another, depending on the relative market power of those firms and the sensitivity of the supply and demand of their products to price changes. The incentive of the individual firm is to attempt to garner as much of the economic profits generated by a product as the market will

allow. But rents earned initially by one firm may eventually flow to others if linkages are strong. Indeed, part of the premise of targeting is that the benefits will be shared within the economy and not be held only by the targeted industry. To the extent that international markets are as closely interrelated as are domestic markets, however, it may be impossible to ensure that the economic gains remain within the domestic economy.

Role of Government Support

All governments of advanced industrialized countries provide some support to emerging high-technology industries. The major industrial countries of Europe, as well as Japan and the United States, support essentially the same industries. How these particular industries were chosen is in itself an interesting question--these choices are far from independent of each other. Each industry certainly can argue for a special place on the nations' economic and research agendas, but given some restrictive criteria for "strategic industry" status, all of them cannot be targeted at the same time. One suspects, and government pronouncements confirm, that the commonality of the targeted industries in the developed market economies stems more directly from each government's looking at the activities and priorities of its economic rivals. Thus, for example, microgravity processing is an internationally targeted industry despite its questionable economic returns.

All four industries benefit from federal policies that are not examples of explicit strategic trade targeting. The U.S. government directly undertakes and supports under contract a variety of R&D activities based on agency missions. Improved commercial competitiveness in emerging industries is viewed only as a subsidiary benefit of these programs.[22] Government procurement in the pursuit of objectives such as public health, national security, and space exploration often has differential and positive effects on new technologies and the industries that employ and develop them. The federal tax code also favors research and development in several different respects.[23] Finally, local, state, and federal actions--for example, funding for science education and regional economic development programs--also may encourage these R&D activities.[24]

Government support usually is provided for research and development that is pertinent to the mission of the agency offering that support. In the broadest terms

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22. A recent Defense Science Board analysis turned this logic on its head, arguing that commercial competitiveness itself was a major national security attribute and thus a legitimate objective of national security policy.

23. Congressional Budget Office, *Federal Financial Support for High-Technology Industries* (June 1985), pp. 19-30.

24. Congressional Budget Office, *The Federal Role in State Industrial Development Programs* (July 1984), Chapter II.

this spending can be seen as correcting the general market failure leading to underinvestment in research and development by the private sector. With the exception of biotechnology, the amount of direct financial support to the four industries is not large--between $100 million and $300 million per year. Biotechnology receives an estimated $2.7 billion annually.[25] These estimates do not include indirect support through tax credits for R&D, nonspecified support for university research, the cost of space transportation (in the case of materials processing in space), or other support for research projects that is not specifically focused on one of the four industries but may be relevant to it.

Equally significant is the establishment of what may be termed auxiliary policies, and the government's acknowledgement that a particular industry has a special, or favored, status. Auxiliary policies may include standard setting and other regulations that indirectly support an industry. For example, establishing standards and streamlining regulatory processes may be more important than additional spending in agricultural and pharmaceutical applications of biotechnology. Support for the National Aerospace Plane by the National Aeronautics and Space Administration (NASA) and the Defense Department is, in part, meant to encourage the development of new materials, but it should not be considered targeted support. In addition, support by a government agency can act as a signal to private investors or even to other government agencies that a particular industry or technology is considered to be special, thus implying some continuing level of government support and perhaps reduced risk to the private investor. It may, therefore, be misleading to focus solely, or primarily, on a government's financial support as a measure of its commitment.

Apart from research that is directly relevant to government procurement (so-called mission-oriented research), current government support for emerging-technology industries distorts "normal" economic decisions; in fact, it is intended to do so. Whether such support contributes to or detracts from the net national welfare remains an open question. Given that some governments support certain industries in the hope of improving the national economic welfare, others will do the same so as not to appear to be lagging behind or ignoring the nation's economic interests.

CURRENT POLICY AND NEW DIRECTIONS

The formal statements of the Administration's policy toward industry explicitly reject targeting as a means for achieving gains from trade. Nevertheless, "competitiveness" is often noted as a secondary justification for large expenditures by federal agencies to support research and development. In addition, several new, but small, programs are more directly focused on the prospect of future gains in international markets.

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25. Office of Technology Assessment, *New Developments in Biotechnology: U.S. Investment in Biotechnology* (July 1988).

While these measures stop short of the command-and-control type of policies and programs implied by full acceptance of strategic targeting, they reflect the philosophy of targeting and represent a new direction in U.S. policy toward industry.

The Mainstream of Current Policy

U.S. tradition holds that government should have a minimal role in steering resources. If domestic markets are workably competitive, then resources flow to those industries that produce the goods and services for which consumers are most willing to pay. Business firms continually examine new technical possibilities to make sure that the mix of the resources they employ and the output they produce is the one that maximizes their profits. These competitive incentives maximize national income and economic well-being, for the given distribution of income and underlying wealth. This theme can be extended to international markets; free trade among nations allows global resources to be employed in accord with their relative scarcity in the production of those goods and services that best satisfy the preferences of consumers. World economic welfare is thus maximized, increasing with growth in the labor force, consumers' decisions about how much to save, and technological progress.

This policy emphasizes the importance of having the right macroeconomic conditions. Allowing the value of the dollar in international exchange to adjust downward encourages new exporters--including emerging industries--and moves the overall trade account toward balance. A more balanced federal budget, higher national saving, and lower interest rates would provide a more favorable environment in which emerging-technology industries could thrive. These industries would be well positioned to take advantage of the favorable economic climate and could be expected to "win" on their own, without government support.

Current policy also recognizes that the government may have to intervene to correct structural problems, or market failures, that inhibit the development of new industries. Government aid is rendered through support of generic R&D, improved education, or other general actions that are not targeted toward any particular sector or industry. Emerging-technology industries are most likely to benefit from this broad support, because they make greater use of the activities generated by it. In the absence of government support, market failures could hinder the development of emerging-technology industries.

As the cases examined in this report illustrate, the U.S. government currently employs a diverse set of policy tools to support emerging industries. The government encourages cooperation in research and development among firms within industry clusters, and also subsidizes a significant portion of the national research agenda. With only a few exceptions related primarily to national security, health, or energy, current policy excludes the direct targeting and coordinating government support.

A New Direction?

Although current policy does not include a rationale for strategic industries, some recent developments indicate a pragmatic desire to compete on a "target of opportunity" basis. Several new programs and policies, most notably the Advanced Technology Program, are intended to create advantages for emerging industries by offering R&D subsidies. In addition, the Congress has considered several bills that would create a government agency to support new technologies that are identified as having potential advantages in international markets.

Proponents of this approach would support targeted applied research that was aimed at improving the ability of selected U.S. firms to compete in world markets. Industries or firms would be targeted for support because they show some promise of success in the long run but cannot obtain sufficient private-sector support. By choosing the best projects among available candidates--that is, those deemed most likely to succeed--the government is explicitly asked to judge the value of supporting a particular activity. These judgments entail picking a diversified portfolio of projects, some of which can be expected to "win" and all of which, even the losers, can be expected to create some public benefits. This approach views trade as a rationale for government support, but there may be many other justifications for similar support--that is, trade is important, but it is not the only or even the most important factor.

From a trade perspective, the justification for targeted R&D support is viewed as preferable to more protectionist alternatives. If the choice is between policies that restrict the exposure of U.S. firms to international competition and those that focus on promoting a more competitive presence--R&D consortia, research grants, and so on--the latter may be preferred, having both a greater potential for gain if they succeed, and ultimately a lower potential for loss if they fail.[26]

This approach could be carried out by establishing an agency modeled after the National Science Foundation (NSF) and the Defense Advanced Research Projects Agency (DARPA). The NSF is an independent agency that supports basic scientific and engineering research in a variety of fields. Grants, contracts, or loans are typically awarded to projects that are deemed most worthy by the foundation's board, which is a distinguished panel representing the science and engineering communities. DARPA is a research funding arm of the Department of Defense that funds projects presumed to be of value to national security. In contrast to NSF, DARPA primarily funds projects classified as applied research.

Although they have very different missions, the two agencies have a similar approach to funding decisions. Both agencies expect that the supported research will

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26. Jagdish Bhagwati, *Protectionism* (Cambridge, Mass.: MIT Press, 1985), pp. 98-99, argues that prescriptive policies that must ultimately be proved in the market are unambiguously superior to proscriptive policies that ultimately shield national industry from the international market.

either lead to a technological breakthrough or produce spillover benefits. Such benefits would be primarily in the form of the ongoing support and education of the researchers involved, who may be able to make productive use of the knowledge and skills gained, even in a failed effort.

The recently established Advanced Technology Program (ATP) of the National Institute of Standards and Technology was also based on this model. The program is intended to accelerate commercialization of new technology by encouraging U.S. companies to form joint R&D consortia. It does so by providing support offices, technical assistance, and in some cases, funding. The ATP recently announced its first group of funding grants totaling $9 million.

This approach, however, raises the issue of displacement--that is, to what extent would government-supported R&D simply displace what the private sector would otherwise fund on its own? Alternatively, one might ask whether such government-funded research could be accomplished simply by reorienting existing government R&D support, in which case the question again becomes one of weighing the value of the current research agenda against the proposed new agenda. Finally, if this new approach were to require new funds, the questions of where such funds would come from, and how much to provide, would have to be addressed.

Another problem is the selection of criteria for choosing among technologies and applicants for government support. As pointed out above, such choices are difficult to make on technical grounds, and even more difficult to make in a political arena. Although many organizational aspects of this approach have been analyzed and debated, few operational details have been worked out.[27] A lingering concern is that resources that might otherwise be dedicated to research would be redirected to efforts to gain even larger sums from government programs.

CONCLUSION

The ideas developed by advocates of strategic targeting incorporate many previous suggestions for industrial targeting. The theory of strategic targeting, as described generally in Chapter I, helps narrow the focus of these suggestions--it tends to exclude protectionist measures for mature and declining industries--but otherwise does not seem to advance policymakers' ability to "pick winners." It is still difficult to know which industries and which products will succeed. Nevertheless, targeting emerging technologies through support for R&D has the potential advantage of creating general benefits for the economy.

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27. For a discussion of organizational and operational considerations, see Congressional Budget Office, *Using R&D Consortia for Commercial Innovation: SEMATCH, X-ray Lithography, and High-Resolution Systems* (July 1990), pp. 98-112.

The arguments that have been developed for and against industrial targeting generally continue to hold with respect to strategic targeting of emerging-technology industries. Opponents point out that such targeting of one industry must come at the expense of others. In addition, the empirical data available to policymakers is insufficient for them to make correct decisions, and the political process rather than the economic process is likely to dominate such decisionmaking. Moreover, the international linkages among corporations create too many avenues by which gains can be siphoned out of the domestic economy.

Advocates of pursuing a targeting strategy argue that international markets are far from free: competitor nations support their industries and, to avoid losing economic resources to foreign monopolists, the United States must offer similar support. In addition, emerging-technology industries offer potential economic rewards if U.S. firms dominate these new markets. If foreign firms win these markets, the U.S. economy would lose. Technological advancement depends on a synergy of activities; unless a country maintains an active presence in some key activities, it may lose the others. Finally, the United States now supports many industrial activities, which constitutes an implicit industrial policy. This policy could be made more effective if it were more explicit.